APU ENGINE

4. Accessory Drive Section

   A. The accessory drive section consists of a gear reduction drive in a housing attached to the compressor inlet housing. The accessory drive housing mounts or provides mounting pads for the following accessories:

      Centrifugal Switch Assembly

      Fuel Pump and Control Unit Assembly

      Starter Motor

      Cooling Air Fan

      Oil Pump

      Tachometer Generator

      Generator

   B. The arrangement of gears in the accessory drive section is such that the starter motor drives the compressor, turbine and all accessories during the initial phase of starting. A screened inlet provides air for a shaft driven fan which supplies cooling air for the oil cooler and the generator.

5. Operation

   Ambient air enters the compressor through the screened opening and passes through the first stage compressor then through crossover ducts into 'the second stage compressor. From the second stage compressor the compressed air goes through a diffuser and then into the turbine plenum casing, part of this air goes on to the combustion chamber and the mixture is injected into the air in the combustion chamber and the mixture is ignited. Continuous combustion then occurs to burn the mixture, thereby adding energy to the compressed air before it is directed to the turbine section. The gaseous mixture is directed to the nozzle assembly which guides and greatly increases the velocity of the gases against the blades of the turbine wheel to make the wheel rotate. The turbine wheel is thus utilized to convert the velocity and temperature of the burning gases into rotational mechanical energy. The cooler, low pressure exhaust gases are discharged from the turbine through the exhaust flange. A portion of the power developed by the turbine is used to drive the compressor and engine accessories and the remainder is available for output shaft power and compressor bleed-air.

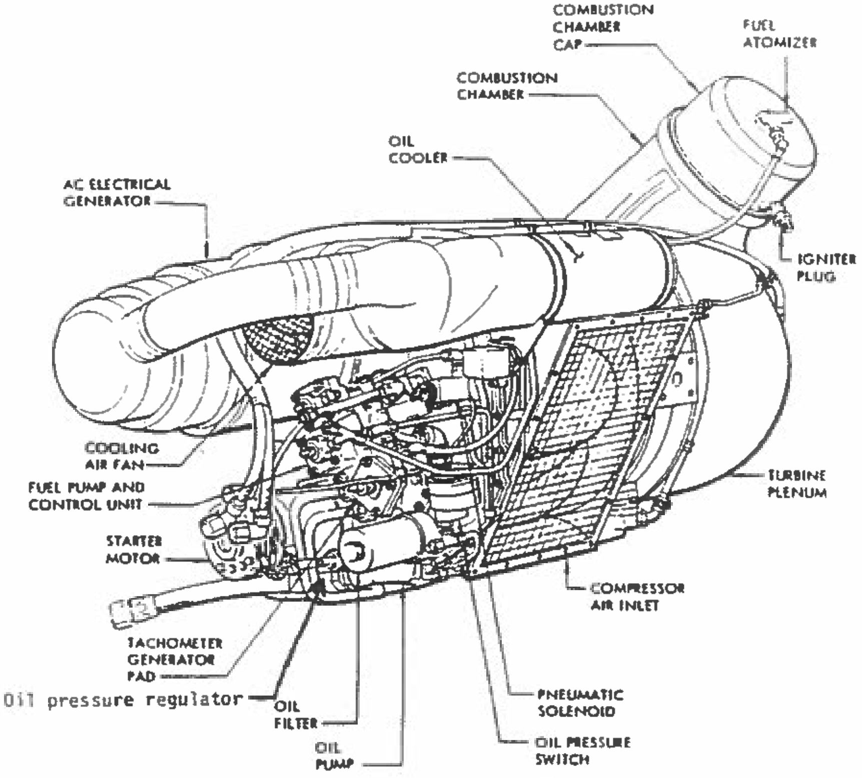
APU LUBRICATION SYSTEM

1. General
   A. Lubrication of the APU turbine engine is by a self-contained, positive pressure, dry-sump system, which cools and lubricates all gears and bearings in the engine by providing a pressurized and splash supply of oil. The components of the system are the oil pump, oil cooler, and oil tank.

   B. When the unit is started, the pressure pump draws oil from the oil tank and delivers it under pressure to the accessory drive section and to the bearing between the second stage compressor and the turbine. The oil drains into the accessory drive housing sump and into the second stage compressor and turbine bearing cavity. The scavenge pump draws the oil from the sump and bearing cavity and pumps it through the oil cooler back into the tank.

2. Oil Pump
   A. The oil pump consists, of separate pressure and scavenge pumps, a pressure regulating valve, an oil filter and filter bypass valve. The oil pump is installed on the accessory drive gearbox.

   B. The pressure and scavenge pumps are driven by a common shaft. The pressure pump is a two gear, positive displacement pump which supplies oil under pressure to the bearings, gears aria shafts of the turbine engine. The scavenge pump is a three gear positive displacement pump which scavenges oil from the accessory drive gearbox oil sump and from the bearing cavity between the second stage compressor impeller and the turbine wheel. It returns the oil through the oil cooler into the oil tank. External outlet and inlet lines are connected to threaded ports in the body, but scavenging from the accessory drive gearbox is through an internal opening between the oil pump and the gearbox



C. The maximum delivery pressure is regulated by a spring-loaded relief valve contained within the pump body. The function of this valve is to open when the pressure pump pressure exceeds 90 psig system pressure,thus allowing oil to bypass back to the inlet side of the pressure pump to maintain a nearly constant system pressure.

Oil pressure shall read 95 +/-5 psig.

NOTE: On airplanes incorporating the orificed anti-siphon oil line, the no-load, steady state oil pressure will read 10-13 psig lower than specified (77 psig minimum). If observed pressure drop is greater than this, orifice size should be checked (orifice dimension is 0.04 - 0.052 inch).. If orifice not within specified dimension, orificed tube should be repaired or replaced.

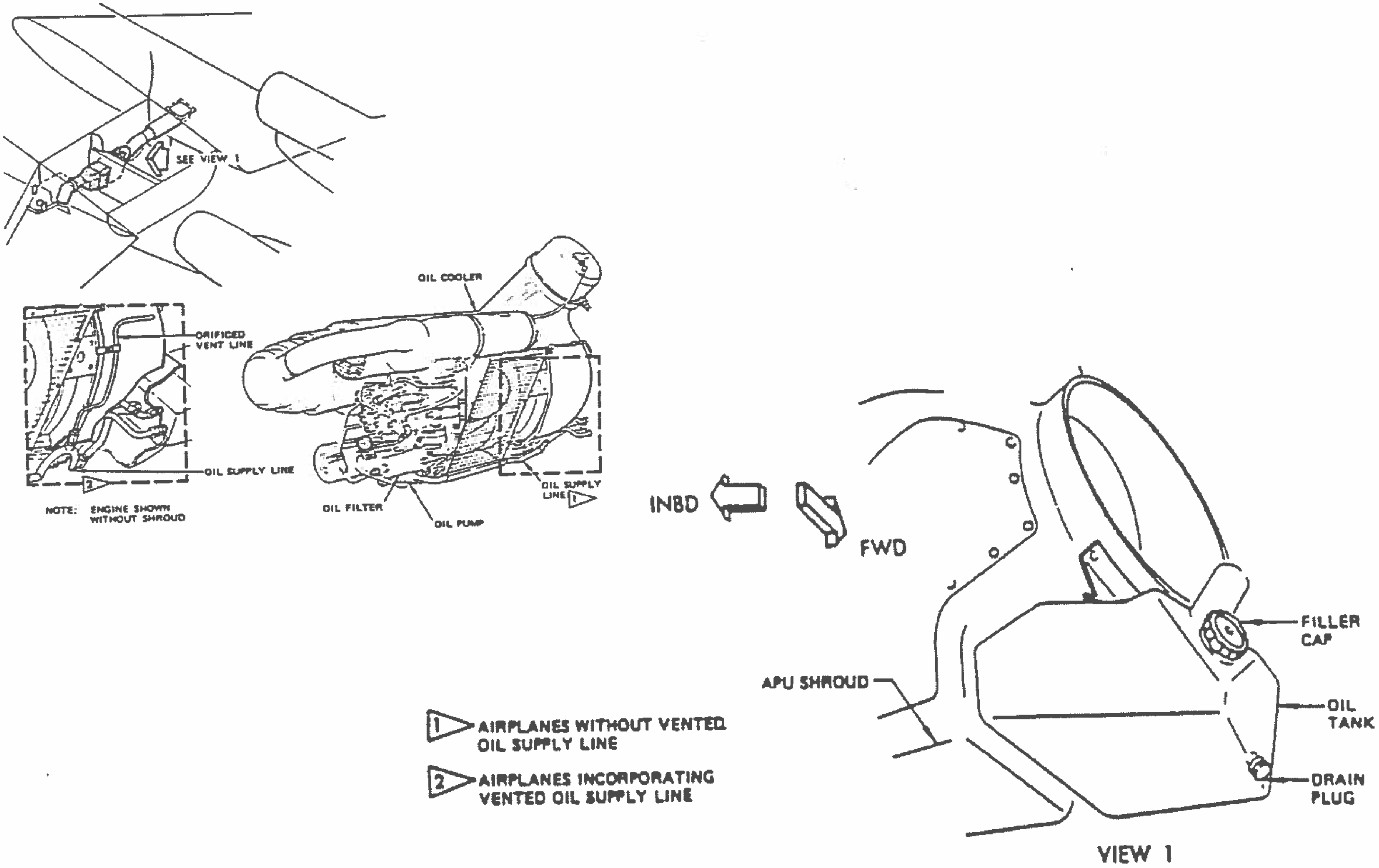
D. The oil filter is located on the oil pump. It filters all the oil flowing from the pressure pump. The filter base is integral with the pump body. A removable case screwed into the base encloses a replaceable filter element.

E. The filter bypass valve is a spring-loaded relief valve contained within the pump body. The function of this valve is to yield to pressure slightly in excess of normal filter resistance, so that if the filter should become blocked, oil is permitted to bypass the filter and maintain a flow through the system.

3. Oil Cooler

The oil cooler, installed on the upper aft side of the power unit is a cylindrical unit. constructed of mechanically bonded aluminum tubes housed in a shell. Oil delivered by the scavenge pump passes around the tubes in the cooler before returning to the tank, while air supplied by the cooling fan flows through the tubes and cools the oil.

APU LUBRICATION SYSTEM EQUIPMENT LOCATION



APU LUBRICATION SYSTEM

4. Oil Tank -98

   The oil tank contains the supply of oil for the system. It is mounted on the left end of the engine shroud. Oil is drawn from the tank by the pressure pump and returned, through the oil cooler, by the scavenge pump. An air-oil separator in the tank separates the oil from the air going through the tank to the vent.

5. Oil Tank -98C/CK

   A. The oil tank contains the supply of oil for the system. It is mounted on the right end of the engine shroud. Oil is drawn from the tank by the pressure pump and returned, through the oil cooler, by the scavenge pump. An air-oil separator in the tank separates the oil from the air going through the tank to the vent.

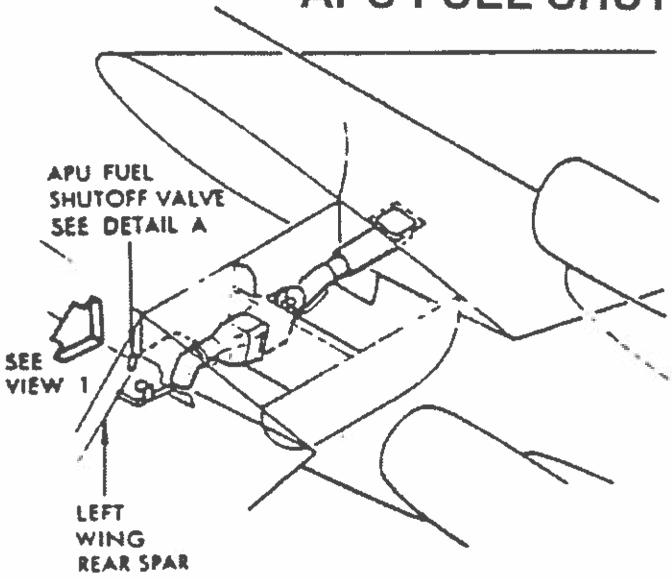
   B. An orificed vent, located to the right of the APU aft engine mount, is attached to the oil supply line. The purpose of this vent. is to break the siphoning action caused by inflight wind-milling.

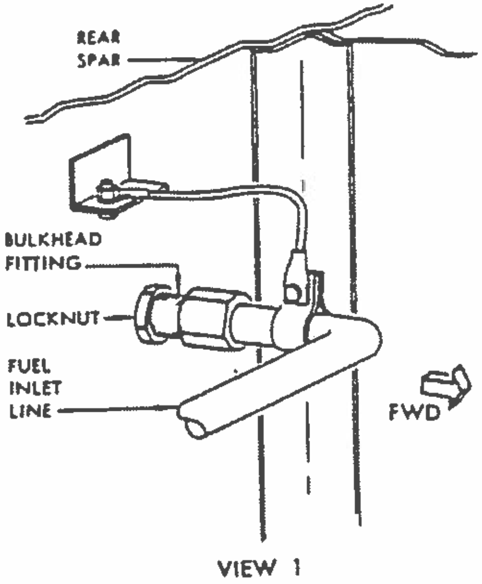
6. Operation

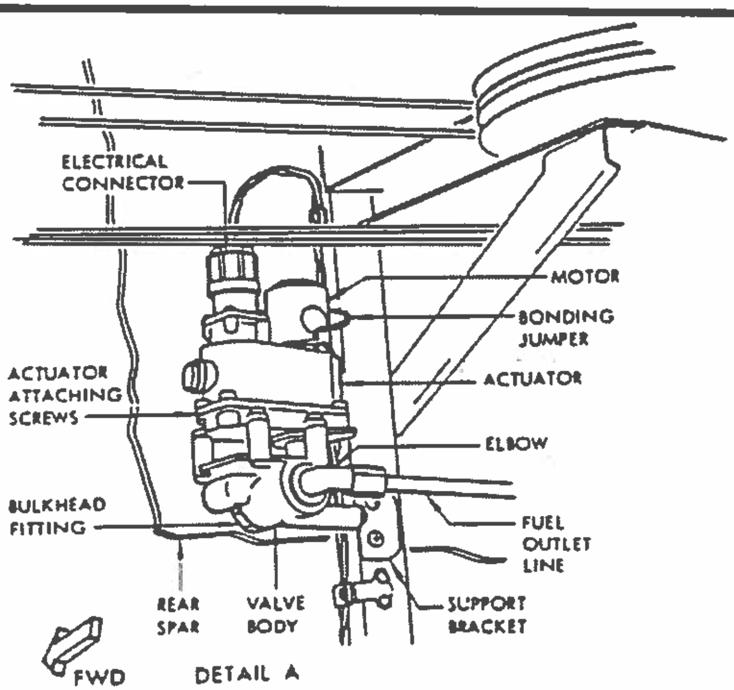
   A. When the unit is started, the oil pressure is supplied by the oil pressure pump gears through the oil pump filter. If the filter is clogged, the bypass valve opens to permit continuing oil flow. From the oil pump, the oil is routed to the accessory drive gearbox and to the bearing between the second stage compressor impeller and the turbine wheel to provide pressure and splash lubrication for the engine gears and bearings. An oil pressure regulator valve in the oil pump operates to maintain the output oil pressure at 90 psig at I00 percent governed speed.

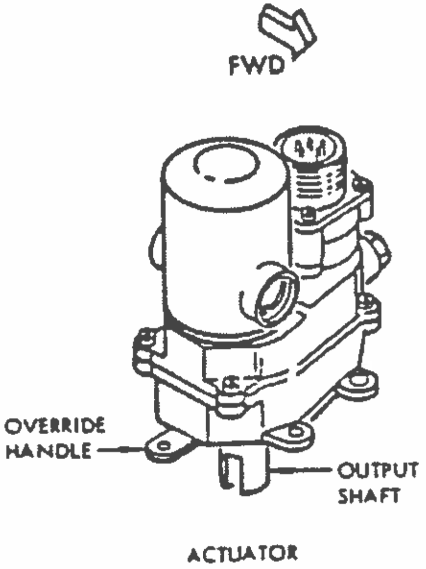
   B. Lubricating oil in the unit drains into the accessory drive gearbox oil sump and into the second stage compressor and turbine bearing cavity. It is pumped from the sump and cavity by the oil scavenge pump gears. Scavenge oil flows through the oil cooler back to the coil tank. Any air trapped in the second stage compressor and turbine bearing cavity is released through the oil tank vent line into the turbine exhaust.

APU FUEL SHUTOFF VALVE INSTALLATION









APU ENGINE FUEL & CONTROL SYSTEM

1. General

   A. The APU engine fuel-and control system supplies fuel from the airplane fuel system to the APU and automatically meters the flow rate to match speed and loading requirements.

      (1) On airplanes with single thermostat system, the system consists of a fuel control unit, a control thermostat, combustor unit, a low pressure fuel control unit, and various control valves.

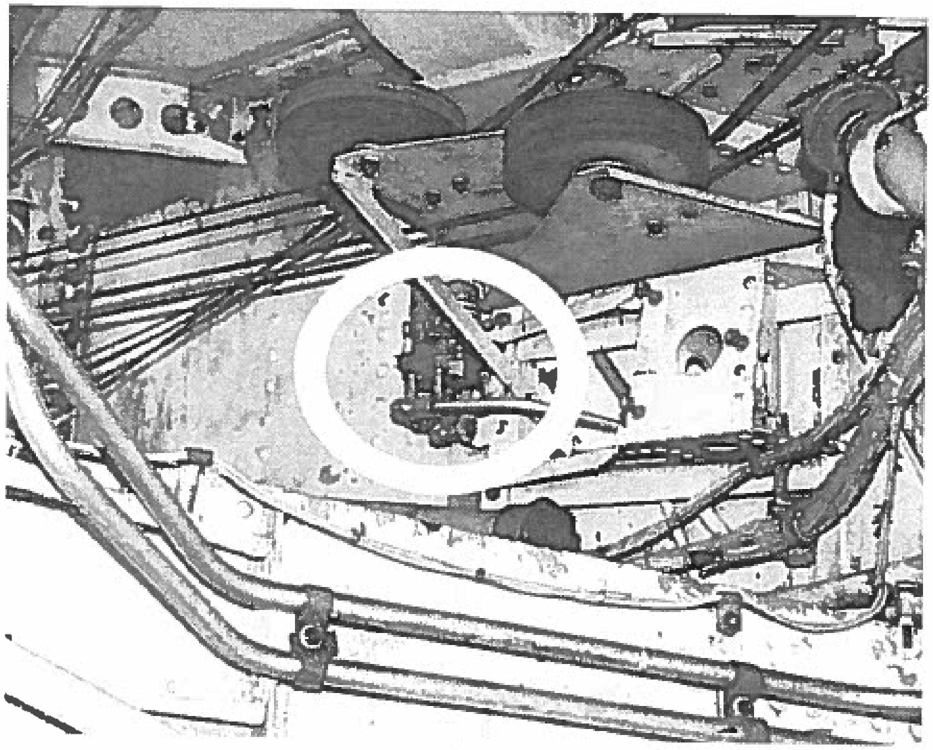
      On airplanes with dual thermostat systems, the system consists of a fuel control unit., acceleration and over-temperature control thermostat, combustor unit, a low pressure fuel filter, and various control valves.

   B. With the airplane battery switch and the APU master switch in the ON position, fuel will be supplied to the fuel solenoid valve. When the unit is started, the fuel control unit supplies and regulates the flow of fuel to the fuel atomizer in the combustion chamber. The regulated fuel low controls the acceleration of .the turbine rotor during the starting operation. When a load is applied to the APU, the fuel control unit meters the flow to maintain a near constant speed and a safe operating temperature of the unit.

2. Fuel Shutoff Valve

   The fuel shutoff valve connects the APU fuel system to fuel tank No. 2. The valve is an electric motor-driven rotary-type valve and is mounted on the rear spar of the left wing. Control of the valve is through the APU master switch.

   NOTE: Fuel is gravity fed only on 100C and 233A aircraft. On the 2S2F aircraft, No. 2 tank aft boost pumps will pressurize the APU fuel system.



APU ENGINE FUEL & CONTROL SYSTEM

3. Fuel Control Unit
   A. The fuel control unit is the major component in the fuel system. It is on the APU accessory section. The fuel control unit is driven by the accessory gear train at approximately 10% turbine rpm. The governor, in the fuel control unit, senses turbine speed and regulates fuel Quantity injected into the combustion chamber. This sequence is repeated as a continuous cycle, thereby controlling turbine speed. The fuel control unit is a single assembly made up of the engine-driven fuel pump, fuel filter, acceleration limiter valve, fuel pressure relief valve, fuel solenoid valve, electrical and pneumatic connections and connections for fuel inlet, fuel outlet, fuel pressure gages, and a seal-leakage drain manifold.

   B. The engine-driven fuel pump is a gear-type positive-displacement pump. The pump housing contains a spring-loaded ball-type pressure relief valve which allows fuel to return to the inlet after sufficient fuel pressure is built up in the fuel control unit. A micron fuel filter is located downstream of the pump outlet port and filters all fuel passing from the pump to the fuel control system components.

   C. The governor senses the engine speed and controls the fuel flow into the combustion chamber to maintain the engine speed nearly constant under varying loading conditions. The governor consists of an input shaft, governor cage, flyweights, spring and an adjustment screw and nut. High pressure fuel surrounds the spring-loaded flyweights. At high rpm or over-speed, the flyweights overcome the spring force and open a fuel bypass. Part of the high pressure fuel escapes into the low pressure area of the fuel control unit, thus reducing the fuel pressure and amount of fuel injected into the combustion chamber.

   D. The acceleration limiter-valve consists of an adjusting spring, two diaphragm assemblies and a spring-loaded relief valve. The valve cover is provided with a connection for controlling air pressure, also a fixed orifice which vents the control air to ambient. This orifice tends to bleed out any moisture which may be present in the control air supply.

E. The fuel solenoid valve is a normally closed electromagnetic shutoff valve, and is a component of the fuel control unit. It is screwed into the fuel outlet port. The valve consists of two body assemblies, a coil, plunger and spring. The valve is energized to pass fuel to the combustion chamber when the oil pressure sensing switch closes during a starting operation.

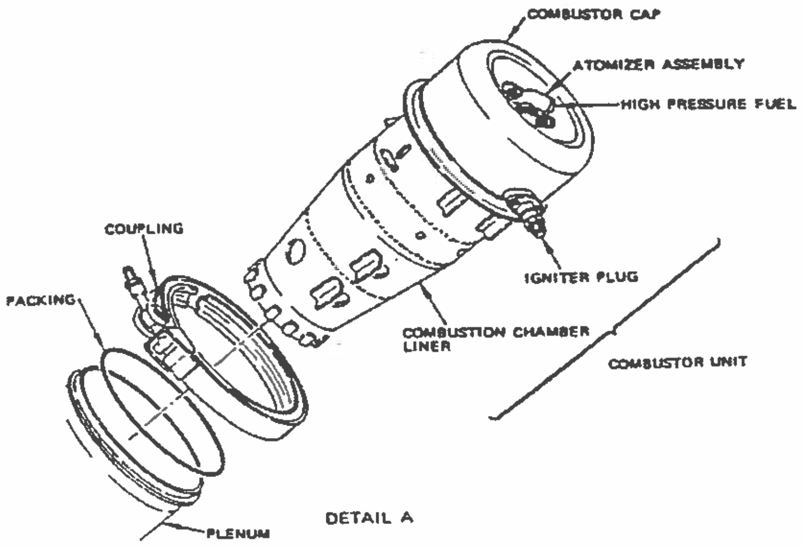
4. Combustor Unit

The atomizer, combustor cap, combustion chamber liner and the igniter plug comprise the combustor unit. The fuel atomizer is a dual orifice type mounted on the combustor cap assembly attached to the flame tube.and plenum assemblies. The fuel atomizer assembly consists of a screen, flow-divider valve, distributor head, and housing The distributor head functions as a dividing passageway, with a core in the center leading to a small orifice plate, and an annulus, leading to a large orifice plate located at the tip. The distributor head and orifice plates located within the housing, are covered by an atomizer nut. Also located within the housing is the screen and flow divider valve. The screen strains all fuel entering the fuel atomizer. The flow-divider valve functions to direct all fuel at lower pressures to the small orifice which provides proper atomization of fuel under these conditions At higher fuel pressures the valve actuates to permit combined flow to both orifices

5. Fuel Drain

The turbine drain check valve is located at the bottom of the turbine plenum assembly. It permits excess or unburned fuel to drain out of the APU. The valve is a spring-loaded check valve that remains open to drain the turbine plenum until the compressor pressure builds up to approximately 8 psi at which time the valve will close. When the APU is stopped, the valve will open as the compressor pressure falls below 8 psi, to drain the unburned fuel from the Unit. A drain line from the valve carries the raw fuel overboard.

NOTE: On Federal Express APU's the check valve is removed and an orifice vent fitting is installed on the plenum.

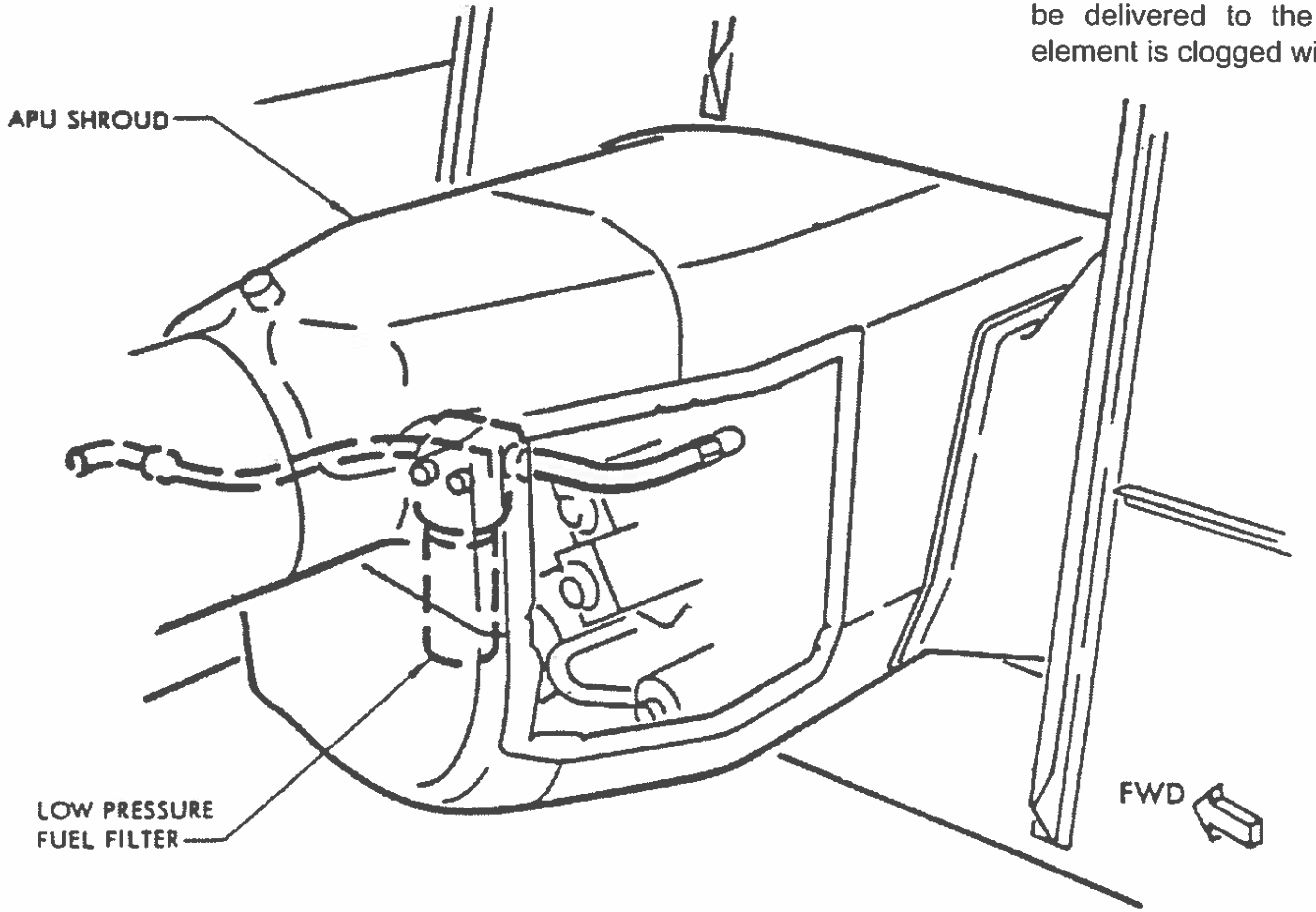


DETAIL A

LOW PRESSURE FUEL FILTER

6. Low Pressure Fuel Filter

   The low pressure fuel filter protects the fuel control unit from foreign material contamination. It is mounted on the inside of the upper end shroud. The filter is a full flow type with a corrugated paper element. A bypass valve will allow unfiltered fuel to be delivered to the fuel control unit if the filter element is clogged with dirt.



APU ENGINE FUEL & CONTROL SYSTEM

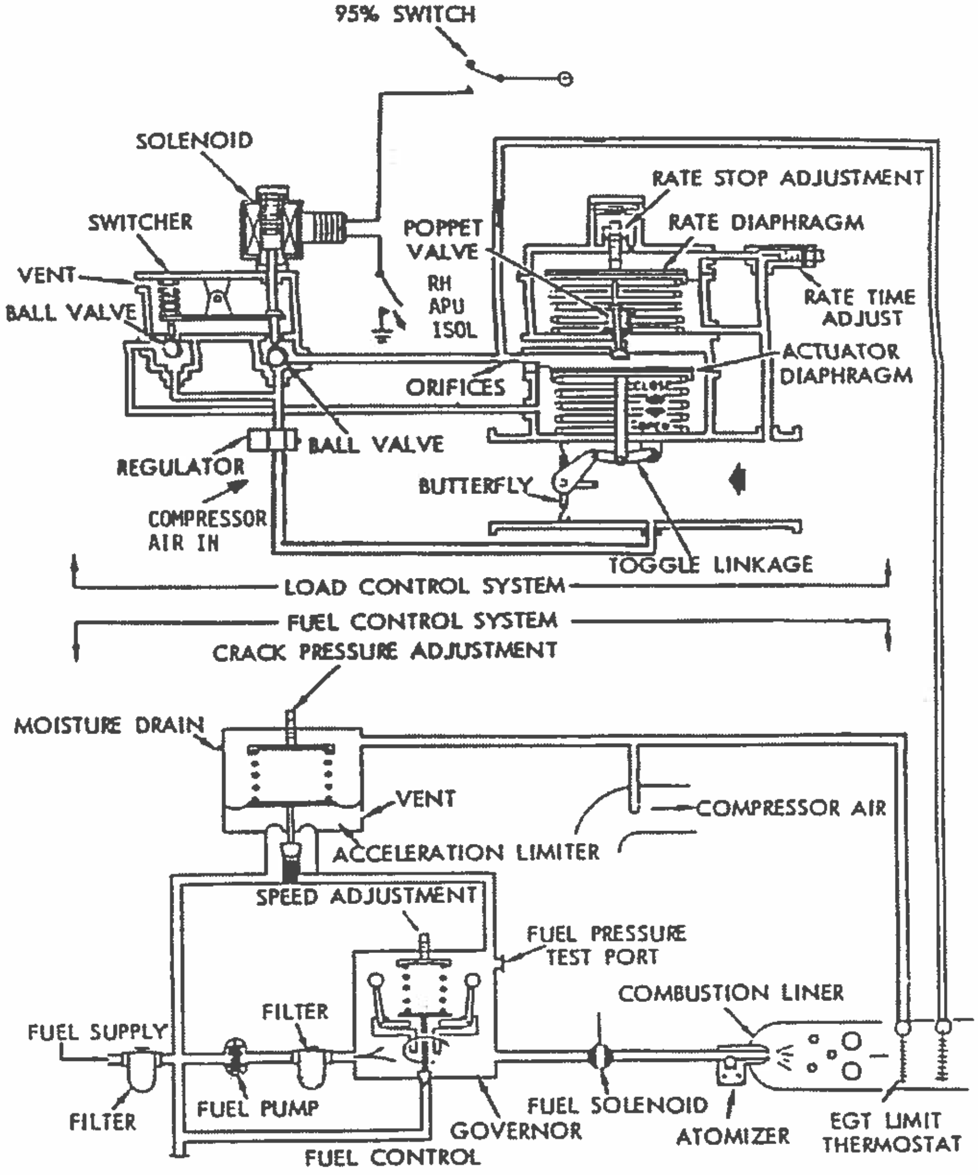
7. Dual Thermostat Control System -98

A. General

The dual thermostat control system is a method of controlling turbine discharge temperature. It consists of an acceleration and over-temperature control thermostat, a bleed load control thermostat. The bleed load control thermostat will be discussed in detail in the APU bleed Air System.

B. Acceleration and Over-temperature Control Thermostat

The acceleration and over-temperature control thermostat, attached to the exhaust flange, projects into the turbine exhaust duct. It consists of an alloy steel housing, spring-loaded ball valve, thermostatic core, and connection for a pneumatic line. The thermostat functions as a temperature controlled orifice over a range of turbine exhaust gas temperature. It is connected by pneumatic line to the acceleration limiter of the fuel control unit. The thermostat is closed when cold and begins to open between 590°C and 620°C when it will bleed control air from one side of a diaphragm in the acceleration limiter valve. This opens the fuel bypass valve which relieves the flow of high. pressure fuel to the turbine combustion chamber.



APU ENGINE FUEL & CONTROL SYSTEM

8. Single Thermostat Control System -98

A. General

The single thermostat control system is a method of controlling turbine discharge temperature. It consists of an APU control thermostat, thermostat selector solenoid valve, and a swing check valve.

B. APU Control Thermostat

The APU control thermostat acts as both an acceleration control thermostat and as a load control thermostat. The thermostat, attached to the exhaust flange, projects into the turbine exhaust duct and is comprised of an alloy steel housing, spring-loaded ball valve, thermostatic core and connection for a pneumatic line. The thermostat is connected through the normally open thermostat selector solenoid valve to the acceleration limiter valve located in the fuel control unit. It functions in the acceleration control n~e until 95% switch actuation. At 95% rpm, the thermostat selector solenoid valve is energized closed, transferring the thermostat to the load control mode.

C. Thermostat Selector Solenoid Valve (Two-Way)

The thermostat selector solenoid valve is a two-way, normally open, electrically operated shutoff valve. When the APU starts, metered compressor discharge air flows to the acceleration limiter, through the valve to the APU control thermostat and to the swing check valve, where it is stopped. At 95% rpm, the solenoid valve is energized closed and the metered compressor discharge air now is directed to the fuel control unit acceleration limiter only.

D. Swing Check Valve (Used with two-way thermostat selector solenoid valve).

The swing check valve is a mechanical, spring-loaded valve located in the line between the APU control thermostat and the APU bleed air valve. The check valve is positioned in the line so that compressor discharge pressure air from the open thermostat selector solenoid valve is prevented from entering the bleed air valve. When the thermostat selector solenoid valve is closed (95% switch actuated), metered air comes form the APU bleed valve through the swing check valve to the control thermostat, causing the thermostat to function in the load control mode.

APU ENGINE FUEL & CONTROL SYSTEM

10. Operation.

A. All components of the APU fuel system are controlled automatically, with the exception of the fuel shutoff valve which is controlled by the APU master switch through the two fire switches, the fire shutdown relay, and the landing gear safety relay to supply and meter the fuel for the APU combustion chamber. Placing the APU master switch in the ON position will open the fuel shutoff valve to deliver fuel to the fuel control unit. For electrical operation of fuel system components, refer to 49-00. The fuel control unit is full of fuel at all times since it is not drained at APU shutdown. The fuel pump delivers high pressure fuel to the fuel solenoid valve, through the fuel control unit, whenever the turbine is rotating. The fuel solenoid valve is opened by the oil pressure switch, when the oil pressure rises to approximately 3 psig, to deliver fuel to the fuel atomizer for. injection into the combustion chamber.

B. On airplanes having a single thermostat system, the fuel control-unit and the control thermostat function during the starting cycle to increase fuel pressure in relation to the increase in compressor pressure. As the compressor pressure increases, with the increase in compressor speed, control air will act on the diaphragm in the fuel control acceleration limiter valve to gradually close the fuel bypass valve, thereby increasing fuel pressure to the fuel atomizer. If the turbine temperature-exceeds a specified value the normally closed control thermostat will open and bleed off some of the control air, this will allow the bypass valve to pass more fuel and reduce fuel pressure at the atomizer, this will in turn reduce the turbine temperature. On airplanes with dual thermostat control system, the fuel control unit and the acceleration and over-temperature control thermostat function during the starting cycle to increase fuel pressure in relation to the increase in compressor pressure. As the compressor pressure increases, with the increase in compressor speed, control air will act on the diaphragm in the fuel control acceleration limiter valve to gradually close the fuel bypass valve, thereby increasing fuel pressure to the fuel atomizer. If the turbine temperature exceeds a specified value the normally closed acceleration and over-temperature control thermostat will open and bleed off some of the control air, this will allow the bypass valve to pass more fuel and reduce fuel pressure at the atomizer, this will in turn reduce the turbine temperature. The fuel atomizer injects correctly atomized fuel into the combustion chamber in a uniform pattern which is unaffected by changes in the fuel pump delivery pressure. Fuel is directed to the primary (small) orifice plate to provide thorough atomization of fuel at low fuel pressure.

APU ENGINE FUEL & CONTROL SYSTEM

As fuel pressure increases, during unit speed buildup, the flow-divider valve will open and allow fuel to flow to both the primary and secondary orifices for correct fuel atomization at high fuel pressures. When the unit reaches governed speed the governor regulates the fuel flow to match power demands thus maintaining a near constant speed under varying load conditions. The governor flyweights act on the sleeve type bypass valve to meter a greater or lesser amount of fuel to the fuel atomizer, resulting in an increase or decrease of turbine speed. In addition to this governor, further over-speed control of the APU is provided by the 110% portion of the centrifugal switch. If the turbine over-speeds, the switch will open and stop the unit. When the unit is stopping the compressor pressure will fall, when the pressure falls to approximately 9 psig the turbine drain check valve will open and drain the unburned fuel from the unit.

C. When a shutdown is initiated the holding relays are de-energized, this in turn de-energizes the fuel solenoid valve to. stop fuel flow to the combustion chamber to stop the unit. If the unit is stopped by placing the master switch in the OFF position, the fuel shutoff valve will remain open until the unit has decelerated sufficiently to deactivate the oil pressure switch at which time the valve will close. If the unit is stopped by pulling either fire switch on actuation of the fire shutdown relay, the oil pressure switch is bypassed and the fuel shutoff valve will close immediately after the stop is initiated. If the unit is stopped due to an over-speed condition or actuation or the remote stop switch, deactivation of the oil pressure switch will arm the close circuit of the fuel shutoff valve, but the valve will remain open until the master switch is placed in the OFF position.

11. Crack Pressure Adjustment

A. For crack pressure adjustment, disconnect the control air line from the acceleration limiter so no air pressure will be applied to the diaphragm.

B. Disconnect the fuel line from the fuel atomizer and connect it to a pressure gauge, readable in one pound increments from zero to one hundred pounds pressure.

C. Motor the engine by the starter until the engine stabilizes at cranking speed and then record the fuel pressure reading. Do not exceed duty cycle limits as that could overheat the electric starter motor.

D. Now adjust the crack pressure adjustment screw as necessary to obtain the correct fuel pressure. After adjustment, lock-wire the nut.

APU IGNITION & STARTING SYSTEM

WARNING: THE CURRENT INVOLVED IN THE IGNITION UNITS IS OF VERY HIGH VOLTAGE AND CAN BE FATAL. BE SURE THAT POWER IS REMOVED FROM THE SYSTEM FOR A MINIMUM OF 3 MINUTES BEFORE MAKING ANY DISCONNECTIONS. AFTER DISCONNECTING A HIGH TENSION LEAD, INSURE COMPLETE DISCHARGE OF CAPACITORS BY IMMEDIATELY SHORTING EXCITER THE UNIT TERMINAL TO GROUND.

1. General

   A. The APU ignition and starting system provides the means of rotating the APU compressor and turbine to starting speed and for igniting the fuel air mixture in the combustion chamber. The system consists of a starter motor, a starter relay, an ignition unit, an ignition plug and a high voltage lead.

   B. During an APU start the starter motor cranks the APU engine and the ignition unit converts a 28 volt d-c power into a high voltage current which is conducted to the ignition plug by the high voltage lead, the resultant high energy spark starts combustion of the fuel. air mixture in the combustion chamber. Initiation and termination of starter operation and ignition unit energization is automatically controlled to occur at the correct time during the starting cycle.

2. Starter Motor

   The starter motor is mounted on the APU accessory drive section and it rotates the APU engine compressor and turbine and all engine driven accessories during an APU start The starter motor consists of a series-wound electric motor, a spring loaded friction clutch and a pawl driven mechanism. When the starter motor is energized it will start accelerating; as its speed increases, centrifugal force throws the pawls into engagement with the ratchet on the accessory drive shaft and the starter will rotate the engine and the other accessories The shock of initial engagement of the pawls is absorbed by the spring loaded friction clutch. When the starter motor is de-energized the engine speed will exceed starter motor speed, the pawls will ratchet on the shaft until the starter motor speed slows to mere the centrifugal force is small enough to allow the springs to retract the pawls

APU IGNITION & STARTING SYSTEM

3. Starter Relay

A heavy duty starter relay is provided to carry the heavy electrical load occurring during starter motor operation. The relay is mounted in the battery control shield. Placing the master switch, or remote start switch, momentarily in the "START" position initially energizes the relay coil. With the switch released, the coil continues to receive current through the APU centrifugal switch and a holding relay. With the starter relay energized the starter motor is energized from the airplane battery, and the start circuit indicator light is energized.

4. Ignition Unit

The ignition unit provides the high voltage current required to produce the spark at the ignition plug. The unit consists mainly of a transformer, a vibrator, a rectifier, a booster coil and a series of capacitors all enclosed in a hermetically sealed metal container mounted-on the outside of the combustion cha~ shroud When the ignition unit is energized the vibrator converts the 28 volt d-c input into a pulsating output, the voltage of this pulsating current is greatly increased.by the transformer and booster coil before it is delivered to the igniter plug.

5. Igniter Plug

The igniter plug provides the high energy spark for igniting the fuel air mixture in the combustion chamber. The principal parts of the igniter plug, which is mounted on the side of the combustion chamber, are the outer casing, a center electrode and a ceramic insulator. The spark that bridges the nonadjustable annular gap, between the center electrode and the outer casing, is of sufficient intensity to vaporize and ignite wet fuel.

6. High Voltage Lead

The high voltage lead conducts the output current of the ignition unit to the igniter plug. The lead consists of an insulated electrical conductor encased in a braided metal conduit with insulated, threaded, connectors at each end. The lead and connectors are shielded to prevent radio interference.

APU IGNITION & STARTING SYSTEM

7. Operation

A. Once an APU start is initiated operation of the ignition and starting system is automatically controlled to correctly sequence the energizing and de-energizing of the starter motor and the ignition unit. Momentarily moving the APU master switch, or the remote start switch, to the "START" position will energize holding relay No. 2 to complete the start relay circuit and energize the start relay. When the switch is released the starter relay remains energized through one set of its internal contacts and the centrifugal switch. With the relay energized, the starter crank indication light will be illuminated and the internal heavy duty contacts will complete the circuit to the starter motor which will rotate and accelerate the APU engine. As the speed increases the oil pressure will rise, when the oil pressure rises to a predetermined value the oil pressure switch will close to energize the ignition unit and the fuel solenoid valve.

B. When the ignition unit is energized the vibrator is supplied with 28. volt d-c power, the vibrator converts this A-C input current to a pulsating current. This pulsating current is fed into the transformer, where the voltage is greatly increased, then passes through the rectifier unit into the storage capacitors. When the storage capacitors are fully charged an air gap will break down, this allows the capacitors to discharge a surge of high intensity current into the primary winding of the booster coil. The secondary winding of the booster coil produces a surge of current, the voltage of which is many times that of the input current in the primary winding, which is delivered to the center electrode of the igniter plug by the high voltage lead. The voltage of this current is sufficiently high to break down the igniter plug air gap and create a high energy spark between the igniter plug center electrode and the outer case to ignite the fuel air mixture in the combustion chamber. The turbine exhaust gases now assist the starter motor to rotate the engine and the engine continues to accelerate.

C. When the engine has accelerated to approximately 35 percent of governed speed the 35 percent switch, in the centrifugal switch will open. The starter relay will be de-energized and this in turn will de-energize the starter crank indicator light arid the starter motor circuit which will terminate starter operation. The engine will now continue to accelerate until it has attained governed speed, at 95 percent of governed speed the 95 percent switch, in the centrifugal switch assembly, will open and break the circuit to the ignition unit to terminate operation of the igniter plug.

APU BLEED AIR SYSTEM

1. General

A. The APU bleed air system is an automatically controlled source of pneumatic power which is connected to the airplane pneumatic system. The system consists of a load control valve, an APU control thermostat, and a differential air pressure regulator.

B. The APU bleed air system supplies pneumatic power by bleeding compressed air from the APU compressor section. The amount of air extracted from the APU is automatically regulated, by the APU control thermostat, to provide the maximum amount without overloading the unit. When the unit is started and reaches 95 percent governed speed, bleed air will be discharged into the airplane pneumatic ducts if the air conditioning system is set to receive air.

2. Load Control Valve

A. The load control valve is mounted between the bleed air outlet on the turbine plenum and the airplane pneumatic ducting. The valve controls the bleed load by limiting the bleed airflow to below the amount that would cause excessive exhaust gas temperature. The load control valve consists of the main valve, the actuator, the rate control valve, and the switcher valve. The main valve is a normally closed butterfly valve enclosed in a housing having flanges for clamps on each end. The actuator is attached to the main valve housing and consists of a spring-loaded diaphragm and an actuating linkage contained in a housing which also encloses the switcher valve. The switcher valve is a solenoid operated, two-ball selector valve that directs control air to either side of the actuator diaphragm as required. The rate control valve controls the opening rate of the main valve and consists of a spring-loaded, diaphragm-operated, poppet valve contained in a housing having an adjustable orifice in the control air inlet.

B. When the solenoid is energized, the switcher valve directs control air to the actuator diaphragm to open the main valve and allow bleed air to flow into the airplane ducting. The rate control valve controls the amount and speed of the initial opening of the main valve.

APU BLEED AIR SYSTEM

3. Differential Air Pressure Regulator

   The differential air pressure regulator is attached to the APU upper shroud. It provides a constant air pressure under all ambient conditions to the load control valve. The regulator consists of a cover and a main housing. The housing contains a spring-loaded diaphragm assembly, metering valve and an adjustable relief valve. An outlet port is also provided in the main housing. The cover incorporates an inlet port fitting and encloses an air filter. The regulating pressure of the valve is set at approximately 19.2 psi above ambient.

4. Operation

   A. The APU bleed air system furnishes a regulated supply of compressed air to the airplane pneumatic system and also acts as an overload governor for the APU. The amount of compressed air available is automatically controlled to prevent the APU being overloaded and will therefore vary with the electrical load imposed on the unit.

   B. Placing the APU master switch to the ON position energizes the APU control bus and opens the~APU fuel valve. Momentarily placing the APU master switch, or remote start switch, to the START position energizes a holding relay. This relay in turn energizes the control circuit to start the unit. When the APU accelerates to 95% governed speed, the centrifugal switch closes and arms the load control valve bleed air solenoid circuit. When the air conditioning system is set to receive APU bleed air, the bleed air relay is energized to complete the bleed air solenoid circuit and the load control valve opens.

APU BLEED AIR SYSTEM

C. When the bleed air solenoid is not energized, the switcher valve directs the control air to the underside of the actuator diaphragm to keep the main valve closed. Control air from upstream of the main valve is directed to both sides of the rate control valve diaphragm and, since the pressure is the same on both sides of the diaphragm, the poppet valve remains closed. Energizing the bleed air solenoid opens the primary ball valve in the switcher valve and closes the secondary ball valve. This transfers control air from the bottom to the top of the actuator diaphragm and the main valve opens. When the valve opens, the pressure sensed by the rate control valve opens. When the valve opens, the pressure sensed by the rate control valve drops in proportion to the rate at which air bleeds from the unit. Since the adjustable orifice restricts the bleed off from the top of the rate control diaphragm, the diaphragm will move down and open the poppet valve to bleed some of the control air from the actuator to atmosphere. Reducing the air pressure in the actuator slows down the opening speed of the main valve and the amount it will open, thus preventing a momentary overload of the unit. As the pressure continues to bleed off from the top of the rate control diaphragm, the poppet valve gradually closes. As the poppet valve closes, the control air pressure in the actuator increases and opens the main valve further. When the poppet valve is fully closed, the main valve is fully open. The adjustable orifice is normally set so that the main valve will open in between 12 and 14 seconds.

APU ENGINE CONTROLS

1. General

A. Once an APU start cycle has been initiated control of that unit is fully automatic. The APU engine controls consist of a centrifugal or electronic speed switch, a pneumatic solenoid or tachometer-generator and an oil pressure switch. Additional control is provided by a thermostat which is discussed in the engine fuel and control section. The APU engine controls provide correct sequencing of the starting cycle and protection against over-speed and loss of lubricating oil pressure.

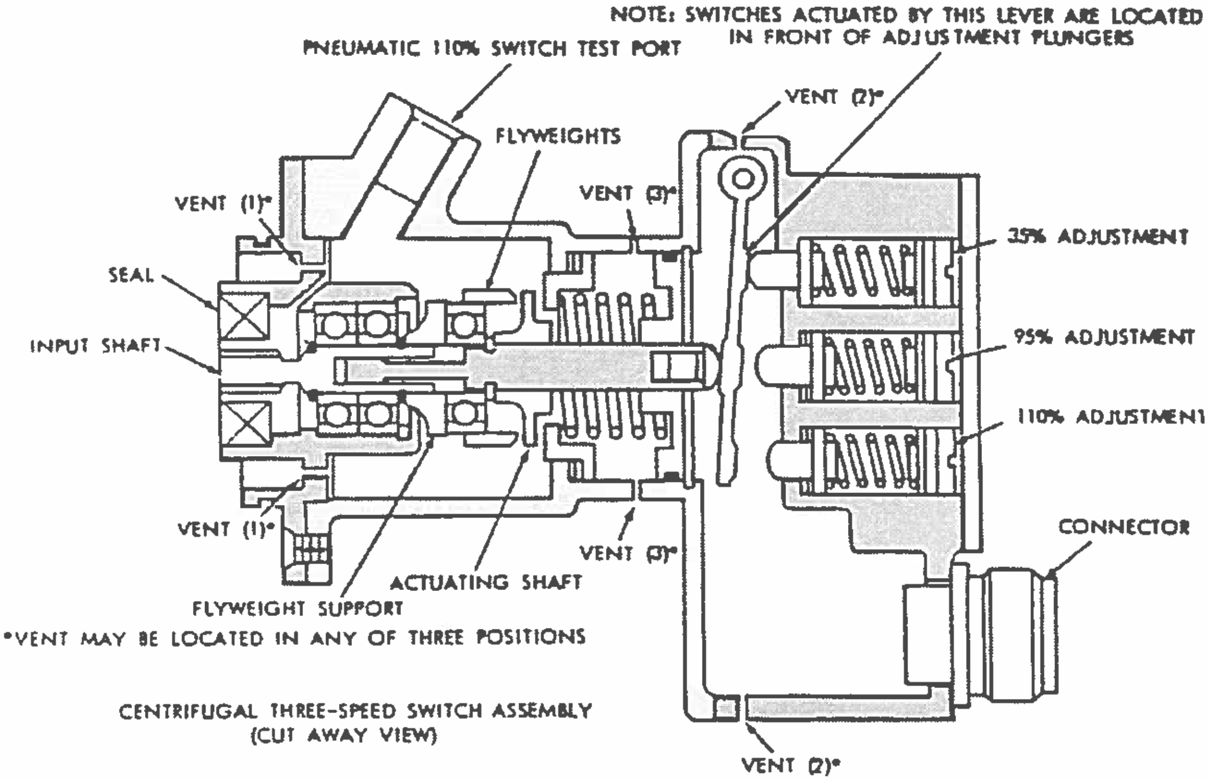
B. The oil pressure switch allows fuel and ignition to be supplied to the engine at the correct time of the starting cycle, the centrifugal or electronic speed switch then terminates starter motor operation and ignition in correct sequence. In addition,. the centrifugal or electronic speed switch prevents bleed air being extracted until the unit has reached governed speed and also provides protection against over-speeding of the unit. On airplanes with a centrifugal switch, the pneumatic solenoid overrides the over-speed portion of the centrifugal switch to stop the unit when the master switch is placed in the OFF position. On airplanes with an electronic speed system, the over-speed oscillator in the electronic speed switch Stops the unit when the master switch is placed in the OFF position.

CENTRIFUGAL SWITCH

2. Centrifugal Switch

The centrifugal switch controls the starting cycle sequence, normal running and over-speed protection for the APU. The switch is mounted on, and is driven by, the engine accessory section. The centrifugal switch assembly consists of a mechanical flyweight type governor, an actuating lever, three spring-loaded push-rods and three snap-action switches.

As the APU accelerates, the flyweights in the switch act against the actuating lever to move it in proportion to engine speed. The spring-loaded push-rods oppose the flyweight force on the lever to decrease the flyweight movement as necessary to ensure that the three switches are actuated in sequence and at the correct engine speed. The switches are mechanically actuated at approximately 35, 95 and 110% of governed engine speed. In addition, an air-operated override provision will operate the 110% switch when the pneumatic solenoid is energized.



CENTRIFUGAL THREE-SPEED SWITCH ASSEMBLY
(CUT AWAY VIEW)

APU ENGINE CONTROLS

3. Electronic Speed Switch

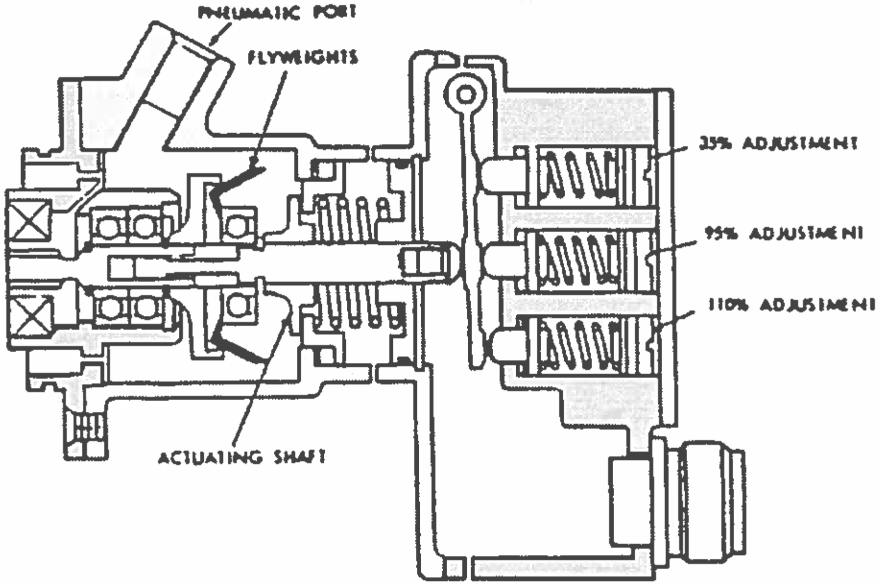
   The electronic speed switch controls the starting cycle sequence, normal running and over-speed protection for the APU. De switch is located above APU on keel beam in the left wheel well.

4. Tachometer-Generator (APU's with electronic speed switch)

   Frequency input to the electronic speed switch is from a tachometer generator, located on the engine accessory drive, which provides the signal that determines the position of the 35% starter cutout relay, the 95% load relay and the 110% over-speed relay.

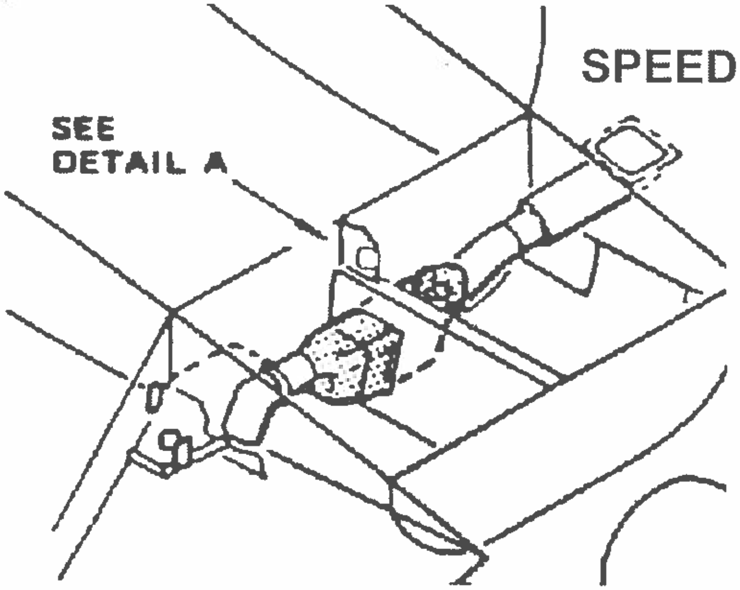
5. Pneumatic Solenoid (APU's with centrifugal switch)

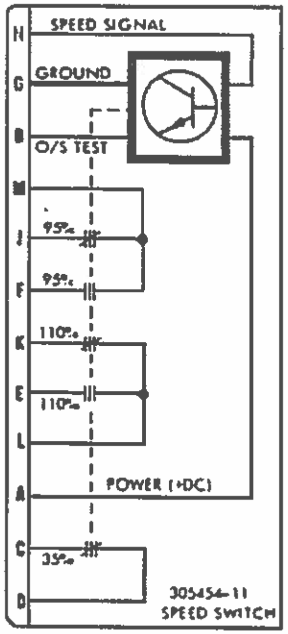
   The pneumatic solenoid overrides the centrifugal switch to stop the APU when the.master switch is placed in the OFF position. It is located on the APU engine. The unit consists of a solenoid-operated valve that controls the flow of control air obtained from the compressor. When the APU master switch is placed in the OFF position, during normal running, the solenoid-operated valve will open and allow compressed air to enter the centrifugal switch. In order for the compressed air to be of sufficient pressure to actuate the 110% switch in the centrifugal switch, the APU must be operating at approximately 70% or above of governed speed.,



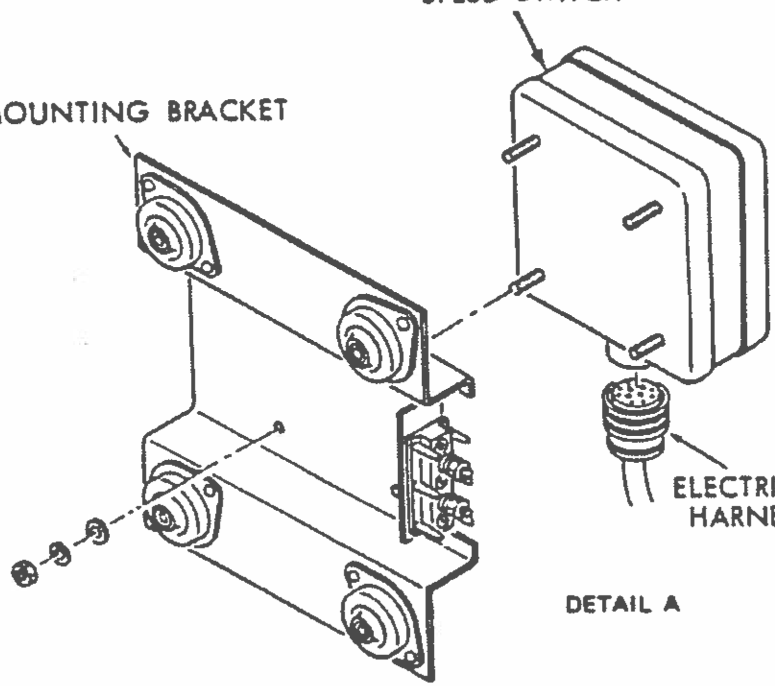
Pneumatic Solenoid

SPEED SWITCH





INTERNAL CIRCUITS



The usual functions of the three switches are:

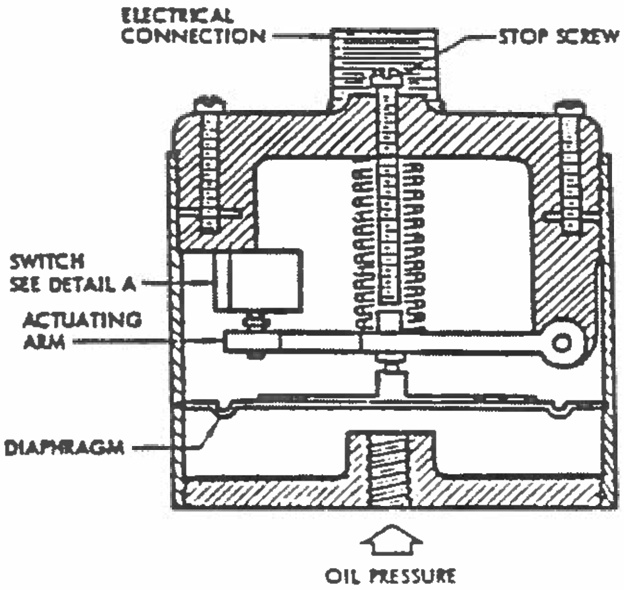
35% - Turns off starter motor.

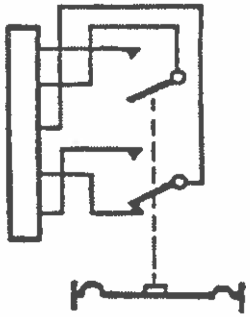
95% - Turns off ignition. Arms loading circuits generator, load control valve, etc.

110% - De-energizes all major electrical components, including. fuel valve, thus stopping unit.

6. Oil Pressure Switch

   The oil pressure switch ensures that combustion cannot be initiated during an APU start until minimum lubricating oil pressure has been built up by the oil pump. It is located on the engine. The switch consists of a housing containing a diaphragm-operated snap-action switch and having connections for an oil pressure line and an electrical connector. When the lubricating oil pressure rises to approximately 3 psig, the switch will be actuated and will close the circuits for the fuel solenoid valve and the ignition unit.





DETAIL A

SWITCH CIRCUIT

APU ENGINE CONTROLS

7. Operation

A. The APU engine controls automatically initiate fuel injection ignition, terminate starter operation, open the unloading shutoff valve and terminate ignition unit operation in correct sequence. In addition, the engine controls provide a protection against the unit reaching an excessive and dangerous speed. For electrical operations of the APU engine control systems, refer 49-00.

B. During an APU start the engine starts rotating when the master switch, or remote start switch, is momentarily placed in the START position. As the engine accelerates, the lubricating pressure rises. When the pressure reaches approximately 3 psig, the oil pressure switch closes. This will complete the circuits to the fuel solenoid valve and the ignition unit and combustion will be started. When the unit has accelerated to approximately 35% of governed speed, the 35% switch, in the centrifugal or electronic speed switch opens. This will break the circuit to the starter relay to terminate starter operation. The unit continues to accelerate. At approximately 95% of governed the 95% switch in the centrifugal or electronic speed switch assembly actuates. This breaks the circuit to the ignition wit to terminate ignition system operation and also completes the circuit to the bleed air solenoid valve and to the hour meter.

C. If the APU over-speeds to approximately 110% of governed speed, the 110% switch in the centrifugal or electronic speed switch actuates and breaks the control circuit. This closes the load control valve and stops the unit. When the unit has decelerated to approximately 10% of the governed speed, the oil pressure switch is deactivated. This arms the close circuit for the fuel shutoff valve and the valve will close when the master switch is placed in the OFF position. For normal shutdown of the APU, the master switch is placed in the OFF position. On airplanes with centrifugal switch system, this energizes the pneumatic solenoid and allows compressed air to enter the centrifugal switch and operate the 110% switch to stop the unit. In order for the compressed air to be of sufficient pressure to actuate the 110% switch in the centrifugal switch, the APU must be operating at approximately 70% or above of governed speed. On airplanes with electronic speed switch system, the over-speed oscillator in the electronic speed switch actuates the 110% switch to stop the unit. When the oil pressure switch is deactivated during deceleration, the fuel shutoff valve , if installed, will close.

APU ENGINE INDICATING

1. General

   The APU engine indicating sections cover the instrumentation, or provisions, for checking, indicating or recording APU conditions and operations. This section provides coverage for the hour meter that records the operating time of the unit and the APU crank light that indicates when the starter circuit is energized. Coverage of the APU crank light.that indicates when the starter circuit is energized.

2. Hour meter (no longer used)

   The hour meter records throughout the APU operating periods to give a visual indication of the number of hours that the APU has been operated since the meter was reset to zero. The meter is basically an electric clock with a digital indicating dial that shows the total running time in hours and tenths of hours. The meter is mounted on a shock absorbing bracket hinged on the inside of the engine accessory access panel and is viewed through a small door in the panel.

3. APU Crank Light

   The APU crank light, on the third crewman's auxiliary panel, indicates when the APU starter is energized. When the APU master switch is momentarily placed in the START position it energizes the starter relay, the APU crank light will be illuminated and remain illuminated until the 35% switch de-energizes the starter relay. The APU crank light therefore provides a multiple indication, it indicates starter relay energization, starter operation, 35% switch operation and starter relay de-energization during a start cycle.

APU EXHAUST GAS TEMPERATURE INDICATING SYSTEM

1. General

   A. The APU exhaust gas temperature (EGT) indicating system measures the APU engine exhaust gas temperature and displays the temperature value on an indicator in the control cabin. The system consists of a temperature sensing probe, a balancing resistor, and a temperature indicator. Copper and constantan wires are used in the airplane wiring; chromel and alumel wires are used inside the APU shroud where higher temperatures are encountered.

   B. Engine exhaust gas temperature is sensed by the thermocouple elements. The heat of the exhaust gases causes the thermocouple to generate dc electrical signals which actuate the meter movement of the exhaust gas temperature indicator. The balancing resistor is included in the circuit to provide a means of adjusting the system.

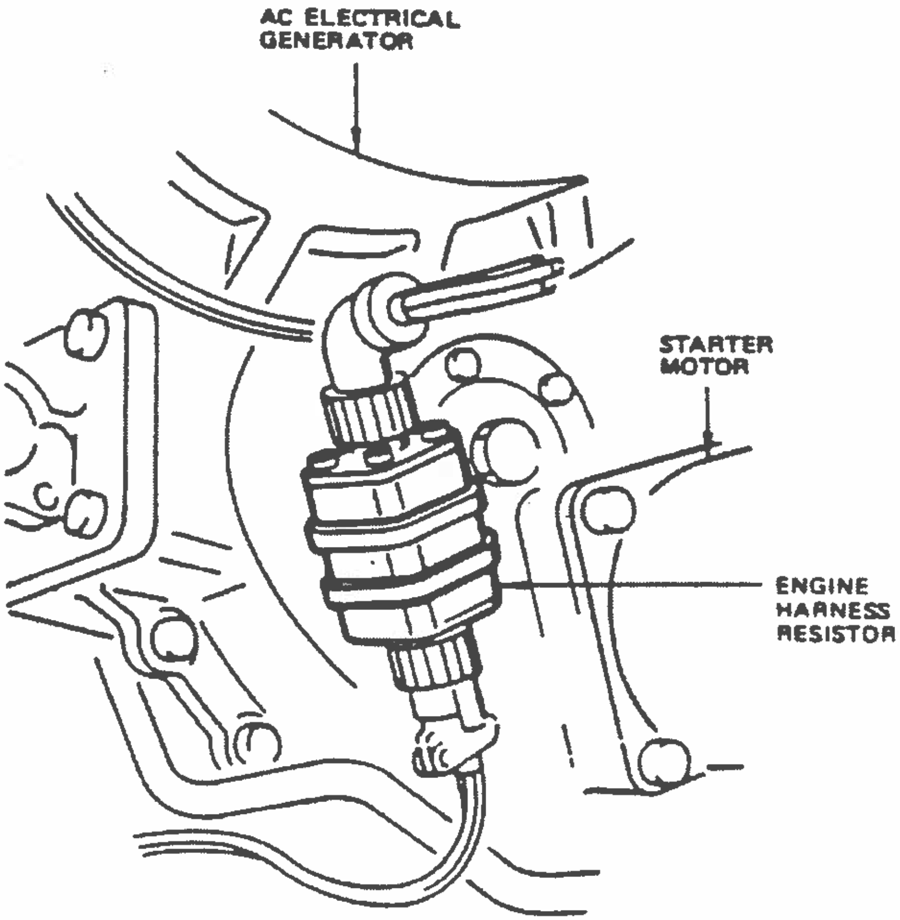
2. Exhaust Gas Temperature Thermocouple Probe

   The thermocouple probe, is a temperature sensing device, mounted on the engine exhaust flange, that senses the temperature of the engine exhaust gases. It consists of two stud terminals, a head, and a thermocouple measuring junction and leads enclosed in a cylindrical shield. The thermocouple junction leads and studs are made of chromel and alumel material. The alumel stud terminal (-) is larger than the chromel stud terminal (+).

3. Exhaust Gas Temperature System Balancing Resistor

   The exhaust gas temperature system balancing resistor is located on the APU control shelf E1-5, It is used for adjustment of circuit resistance. The resistor consists of a spool of No. 24 constantan wire coarse adjustment terminals and vernier adjustment terminals. Since primary adjustment of the resistance is made by cutting off lengths of the wire, a spare resistance spool is included in each resistor.

APU EXHAUST GAS TEMPERATURE INDICATING SYSTEM



(SHOWN ON ENGINE WITH SHROUD REMOVED)

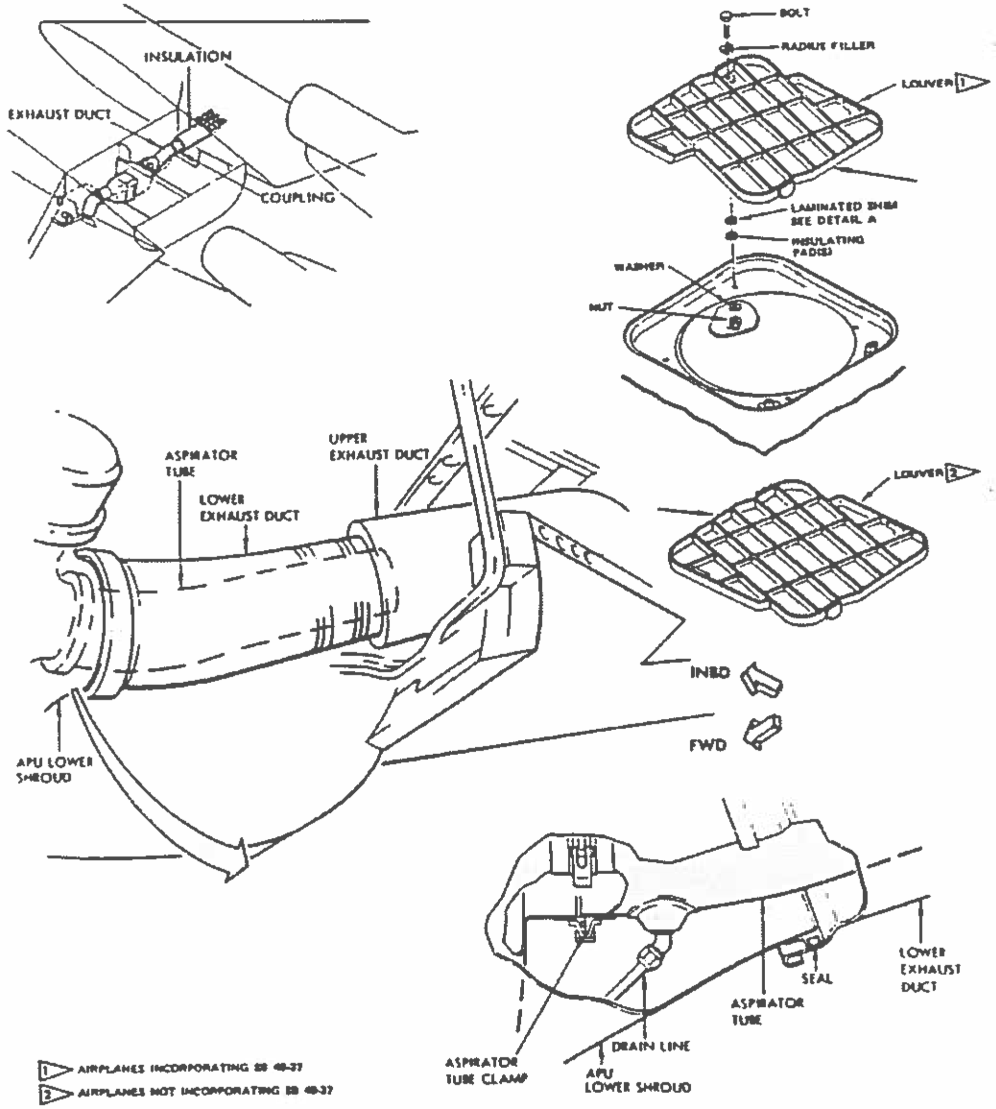
4. APU Engine Harness Resistor (-98C/CK)

   The APU engine harness resistor is used to adjust the EGT probe and harness resistance to a known value for testing the engine before it is installed on the airplane. The resistor is matched to the engine and should not be adjusted in the field. The resistor consists of a variable resistor enclosed in a housing. It is attached to the accessory drive case at approximately 9 o'clock position. The resistor is connected into the alumel (-) lead.

5. Exhaust Gas Temperature Indicator

   The exhaust gas temperature indicator is a specially built, sensitive milli-voltmeter with a dial, graduated in degrees centigrade, in a hermetically-sealed case. The instrument dial indicates a temperature range from 0° to 850°C, with normal and dangerous operating temperatures marked in a color code. The indicator is located on third crewman's auxiliary panel.

APU EXHAUST GAS TEMPERATURE INDICATING SYSTEM



6. Operation

A. The APU engine exhaust gas temperature indicating system consists of a thermocouple probe connected to an indicator and operates on self-generated power. The airplane power is used only for integral lighting of the indicator.

B. The difference in the temperatures at the probe (the hot junction of the thermocouple) and the indicator (the cold junction of the thermocouple) causes electrical signals to be generated in the thermocouple circuit. These electrical signals are proportional to the temperature difference between the two junctions and are measured by the indicator. Since the generated signals correspond only to the temperature difference, the control cabin ambient temperature must be added to this measure temperature difference to obtain the actual temperature of the exhaust gasses; the indicator does this addition automatically. The control cabin temperature, where the indicator is located, is reasonably constant, however small temperature changes in the indicator are compensated with a bimetal (thermostatic) spring, connected to the indicator control mechanism. The indicated exhaust gas temperature is therefore an accurate indication irrespective of prevailing ambient temperatures.

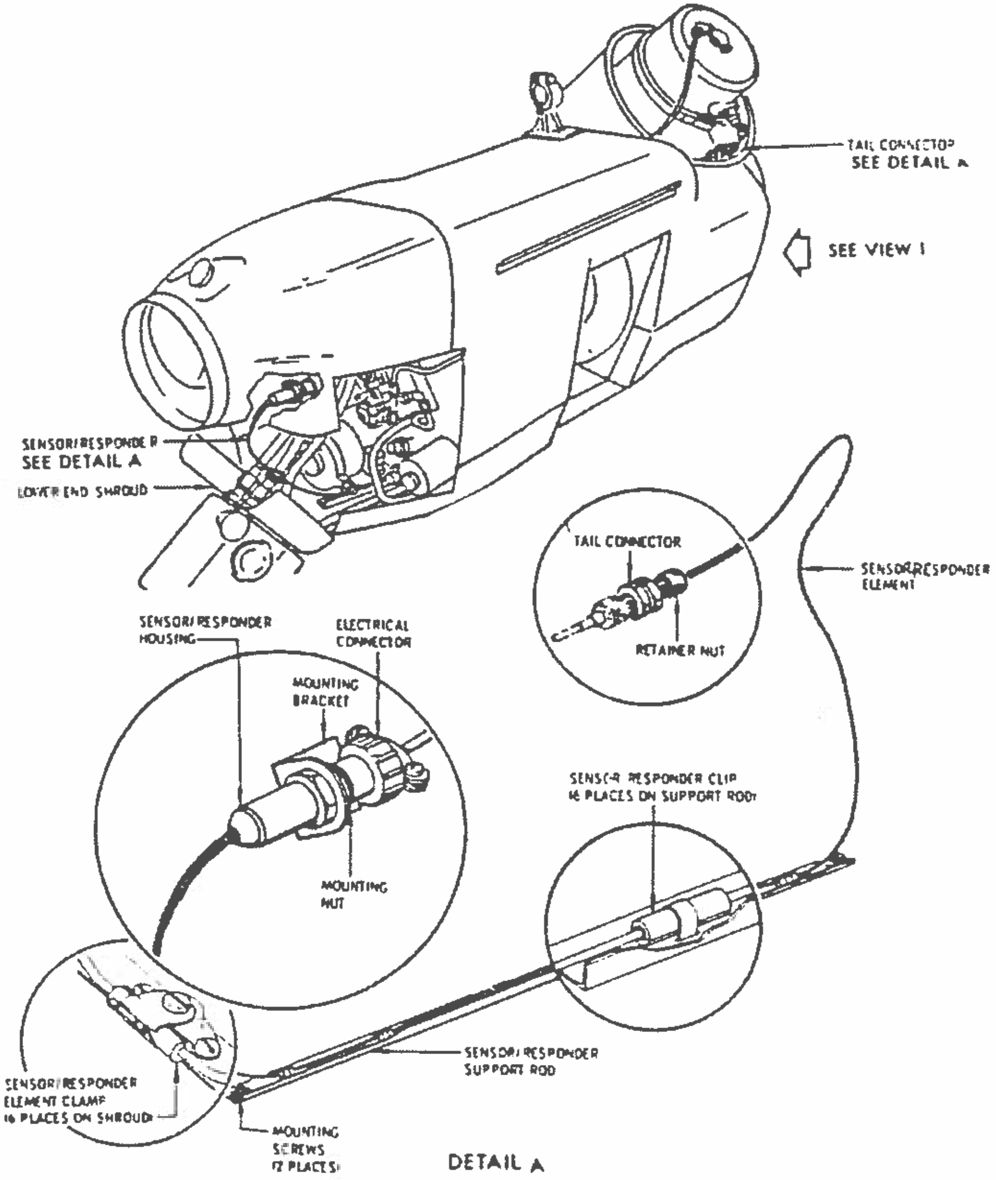
APU FIRE DETECTION SYSTEM

1. APU Fire Detection System

   A. General

   The APU fire detection system provides fire detection within the APU shroud. The system responds to a general overheat condition or a localized fire condition by activating warning lights and an alarm bell and horn. The system includes a test switch to permit testing of the system either in flight or on the ground.

   B. The system consists of a sensor/responder type element around the APU. The element is connected to the operating power unit which actuates the warning lights and alarm bell and horn. There is a warning light and alarm bell in the control cabin, a warming light in the left wing fillet area and an alarm horn in the nose wheel well area. The external light and alarm horn are connected to the system through the landing gear safety relay so that they operate only when the plane is on the ground.



APU FIRE PROTECTION

2. Warning System

   A. Alarm Bell and Horn

      An alarm bell and horn are furnished for warning of a fire in the APU area. They are controlled by a relay within the operating power unit. Power to the alarms is 28 volts DC with circuit breakers on the load control center panel. An alarm cutout switch located on the pilot's fire switch panel and one on the APU ground control panel will turn off the alarm bell and horn and changes the flashing operation of the remote warning light to a steady light. The alarm bell is in the aural warning devices box above the flight engineers panel and the alarm horn is on the right side of the nose wheel well.

   B. Fire Warning Lights

      Warning lights are provided for the APU area fire warning. A fire condition in the APU causes a steady illumination of the warning light on the APU control module in the control cabin and a flashing illumination of the light on the APU ground control panel.

APU FIRE PROTECTION

C. Warning Flasher

A warning flasher is located on the auxiliary power unit control shelf E1-5. The flasher is furnished to cause the alarm horn and APU ground control panel warning light to operate intermittently.

D. Test Switch

(1) A test switch on the APU control module provides a means of verifying system integrity from the control cabin by applying electric power to the detector which causes it to heat up to the alarm value. The test circuit will indicate a failure in the system.

(2) Test power for heating the detector while the APU is not operating is 28 volt dc from the battery transfer bus. Test power for heating the detector while the APU is operating is supplied by the APU run fire test transformer. The transformer is fed by the APU generator.

E. Fire Shutdown Switch

The fire shutdown switch located on the APU control module is used in the APU electrical system to permit APU operation for test purposes and when the fire detection system has malfunctioned. When the switch is in the ARMED (AUTO) position and the fire detection system gives a warning, the APU will shutdown. When the switch is in the OFF (OVERRIDE) position the APU will not shutdown when a fire warning is sounded. The APU should only be operated, when APU operation is being observed or for test purposes, then the fire shutdown switch is in the OFF (OVERRIDE) position.a.

Aircraft equipped with the optional fire extinguishing system (B727-233 at present) will have the following operational differences:

1. Automatic fire bottle discharge - The automatic mode is armed when the auto fire shutdown switch is in the ARMED position. Should an APU fire alarm occur, the fire bottle will be discharged after an 8 to 10 second time delay. Manual discharge will continue to be available should the automatic system fail.

NOTE: To prevent an accidental fire bottle discharge when the fire detection system is tested, the auto-fire extinguishing mode is overridden anytime the fire test switch is positioned to TEST.

APU FIRE PROTECTION

3. APU Fire Extinguishing System

A. General

(1) The APU fire extinguishing system is a gaseous smothering system designed to flood the APU shroud area with an inert gas in case of fire. This system is electrically controlled by switches located on the APU control module in the control module in the control cabin and the APU ground control panel in the left wing fillet area. Freon gas is the extinguishing agent with nitrogen gas used to pressurize the bottles.

(2) A spherical storage bottle for freon together with related tubing is installed in the left wing fillet area. The freon bottle will supply one application of fire extinguishing agent to the fire. The bottle is filled with two pounds of freon.

(3) There are two fire switches with their associated fire extinguisher discharge switches. One pair of fire and discharge switches is on the APU control module in the control cabin and the other pair is on the APU ground control panel.

(4) There is a red indicating disc on the main gear door to wing fairing to indicate if the bottle has discharged due to overheat.

B. Fire Extinguisher Bottle

The fire extinguisher bottle is a spherical steel bottle about 5.3 inches in diameter. It is provided with three mounting lugs, a fill port with a safety discharge plug of fusible metal, a discharge port and a pressure gage. The bottle is filled with two pounds of freon and charged with dry nitrogen to 365 (+/- 40) psi at 60°F.

C. Discharge Line

There is a discharge line from the fire extinguisher bottle to the left forward area of the shroud. A nozzle on the end of the discharge line directs freon gas around the interior of the APU shroud.

D. APU Fire Switches

The fire switch on the APU control module in the control cabin incorporates the fire warning light for the APU in a round handle which has a red translucent plastic cover. The fire switch on the APU ground control panel is a pull-type handle in front of the panel.

APU FIRE PROTECTION

E. Discharge Switches

The pushbutton or toggle discharge switches on the APU control module and ground control panel will not fire the extinguisher cartridge until the corresponding fire switch is actuated (pulled). The discharge switches are adjacent to the fire switches.

F. Operation

The fire extinguishing system is armed by pulling an APU five switch. When the discharge switch is actuated (for at least 1 second), the cartridge in the bottle discharge plug is detonated, breaking the metal sealing disk or rupturing the sealing diaphragm and releasing the freon in gaseous form. The gas is discharged into the APU shroud through the nozzle, thus smothering the fire.